A STANDARDIZED SYSTEM OF TRAINING INTENSITY GUIDELINES FOR THE SPORTS OF TRACK AND FIELD AND CROSS COUNTRY

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Abstract

Accurate quantification of training intensity is an essential component of a training program (Rowbottom, 2000). A training program designed to optimize athlete performance abilities cannot be practically planned or implemented without a valid and reliable indication of training intensity and its effect on the physiological mechanisms of the human body (Olbrecht, 2001; Rowbottom, 2000). Additionally, for sport coaches to make evidence-based changes in the training process, or assess an athlete's physiologic response to a training prescription, valid and reliable measures of training intensity must be used (Olbrecht, 2001; Rowbottom, 2000).

This study developed and field tested a standardized system of training intensity guidelines for the sports of track and field/cross-country, modeled after the standardized system of training intensity guidelines developed, adopted, and in use by U.S.A. Swimming; and explored track and field and cross-country coaches' receptivity to, and perceived utility of, the guidelines developed. This paper: (a) reviews the training intensity guidelines developed, inclusive of the associated physiologic metrics validated in the study; (b) describes a seasonal application of the guidelines; and (c) concludes with supporting commentary from the teacher/coaches interviewed in the study; all of whom uniformly confirmed the utility and applicability of the guidelines.

A Standardized System of Training Intensity Guidelines for the Sports of Track and Field and Cross Country

Introduction

Popular magazines, newspaper reports, clinics, seminars, training books, internet newsgroups, and television programs, disseminate a cornucopia of empirical information describing the views of experts, well-established coaches, and elite athletes on sport training (Friel, 2004). Several of these sources provide training intensity guidelines or have developed training intensity scales consisting of different zones to assist coaches with the prescription and monitoring of training intensity (Friel, 2004).

Many of the methods described in the popular literature, however, are conjectural and/or imply a degree of biological specificity or adaptation that is not really present (Fry, Mortton, & Keast, 1992; Seiler & Kjerland, 2006). In addition, much of the advice given within the popular literature pertaining to training intensity is non-specific, contradictory, and often simply unhelpful (Hills, Byrne, & Ramage, 1998). Because of this, one of the most daunting tasks track and field/cross-country coaches (hereafter referred to as coaches) face is sifting through the popular literature and identifying valid and reliable methods to monitor training intensity (Gambetta, 2007). This can be a difficult task considering many coaches do not have the sport science academic preparation necessary to adequately determine and prescribe workload intensities required to promote the biological adaptations needed to optimize an athlete's performance capabilities (Smith, 2005; Vigil, 1997). As a result, it has been argued that coaches' training recommendations are too often made without precise knowledge of the effects on athletic performance (Hawley, Myburgh, Noakes, & Dennis, 1997). As a consequence, the training adaptations actually induced may differ from those desired, diminishing the effectiveness of subsequent workloads, the training program as a whole, and inhibiting the ability of athletes to succeed (Bompa, 1999; Janssen, 2001; Olbrecht, 2001).

Measurement of blood lactate concentration is currently the most precise method of monitoring training intensity (Maglischo, 2003). The development of valid and reliable training intensity guidelines, based on the blood lactate curve and energy metabolism, has the potential to provide coaches with specific logical directions for the prescription of workload intensities. Therefore, dividing the blood lactate intensity curve into intensity zones and attributing to each zone a major training effect can facilitate coaches' abilities to more objectively plan training programs, and thereby help to limit the occurrence of overtraining.

Over the course of the 2008-2009 academic year the authors' developed and field tested a standardized system of training intensity guidelines (hereafter referred to as guidelines) for the sport of track and field/cross-country, modeled after the standardized system of training intensity guidelines developed, adopted and in use by U.S.A. Swimming. The findings showed that as training intensity increased so did participants' blood lactate concentration, heart rate and ratings of perceived exertion. A Pearson product-moment correlation analysis between the mean values of blood lactate concentration, heart rate and ratings of perceived exertion, and the corresponding training intensity ranges revealed significant positive correlations between mean blood lactate values ($r = .99$, $p < .001$), mean heart rate ($r = .96$, $p < .001$); and ratings of perceived exertion ($r = .99$, $p < .005$). Correlation analyses between heart rate and measures of blood lactate were also positive ($r = .70$, $p >.05$), as were heart rate and ratings of perceived exertion ($r = .96$, $p < .005$). Measures of blood lactate were also positively and significantly correlated to ratings of perceived exertion ($r = .82$, $p <.05$). These findings validated the training intensity guidelines model (Belcher & Pemberton, 2012).

Once developed, the authors explored high school and college coaches' receptivity to and perceived utility of the guidelines. This paper presents an overview of the guidelines (see Table

1) and concludes with supportive commentary from four track and field/cross-country coaches (two high school and two collegiate) to whom the guidelines were distributed for use. The coaches uniformly confirmed that the utility and applicability of the training intensity guidelines in terms of their ability to create training sets, map out season training programs, and knowing which main training effects to expect. In addition, according to the coaches classifying training intensity according to predominant training effects will allow them to better anticipate training outcomes, as well as more easily communicate with sport scientists and other coaches. Use of type of training intensity classification system diminishes the amount of subjectively found when training is classified in only subjective terms, such as hard, easy, light, etc., and can, as this inquiry demonstrates, provides coaches with a common language and uniform classification of training based upon scientific evidence.

The Training Intensity Guidelines & Associated Physiologic Metrics

The guidelines developed and field-tested in this study consists of nine intensity zones condensed into four broad classifications. These classifications were: recovery training, endurance training, speed or sprint training, and economy training (See Table 1). These classifications are described below, inclusive of the validated physiologic metrics.

Table 1
Training Intensity Guidelines Model

Category (Abbreviation)	Intensity / Speed	Lactate (mmol/L)	% of MLSS Heart Rate (HR)	RPE
Recovery (REC)	<80% of MLSS	<1	<90 to 95	<9
Extensive Endurance (E1)	80 to 90 % of MLSS	1 – 2.5	90 to 95	10 - 12
Intensive Endurance (E2)	90 – 95% of MLSS	2 – 3.5	95 - 100	12 - 14
MLSS (E3)	95 – 103% of MLSS	3 – 5	100 - 106	14 - 16
Vo_2 max (E4)	109 – 111% of MLSS	> 6	Max HR	16 - 18
Lactate Tolerance & Buffering (S1)	90 – 100% of max run for 1 to 3 minutes	Max	N/A	19+
Lactate Production (S2)	90 – 100% of max run for 5 to 50 seconds	N/A	N/A	N/A
Sprint (S3)	Max speed for 0.1 to 5 seconds	N/A	N/A	N/A
Economy (Econ)	Race pace or speed at which technique can be maintained	N/A	N/A	N/A

Recovery training (REC). REC is characterized by low intensity training, usually below the aerobic threshold or less than 80% of the Maximal Lactate Steady State (MLSS) velocity. The MLSS is thought to represent a manageable level of anaerobic metabolism that an individual can sustain for 20 to 40 minutes without experiencing fatigue, and represents the maximal intensity at which lactate production and clearance are in equilibrium (Maglischo, 2003; Urhausen, Coen, & Kindermann, 2000). Exercising at an intensity below the aerobic threshold or less than 80% of the MLSS maintains a high rate of blood flow throughout the body without causing acidosis or the depletion of muscle glycogen stores. This allows the muscles to replenish their glucose stores, enhances the rate of recovery and rebuilding processes of the muscles, and permits athletes to incrementally increase the amount of more intense training they can perform. Measures of heart rate (HR) as well as effort sensations associated with a 20 point Borg Rating of Perceived Exertion (RPE) scale should be maintained below the values associated with extensive endurance training (i.e., HR < 90-95% of MLSS and RPE < 9).

Endurance training. Improving aerobic endurance delays the athlete's reliance on the anaerobic metabolism, allowing her/him to run faster in the middle of a race before the onset of acidosis and fatigue. The broad category of endurance training consists of four levels of intensity. These are extensive endurance training (E1), intensive endurance training (E2), MLSS training (E3), and aerobic power training (E4).

E1. Extensive endurance training enhances the rate of oxygen delivery and utilization of both Slow Twitch (ST) and low threshold Fast Twitch (FT) muscle fibers, provided the duration of the run is sufficient to deplete the glycogen stores of the ST muscle fibers that were initially used. It also increases the number and size of mitochondria and improves capillarization, blood shunting abilities, and lactate removal rates, all of which contribute to improvements in both aerobic capacity and aerobic power. Extensive endurance training should be performed at an intensity of 80 to 90% of MLSS pace, with a heart rate approximating 90 to 95% of the MLSS heart rate, and a sensation of effort of 10 to 12 on a 20 point Borg RPE scale.

E2. Intensive endurance training corresponds to a training intensity of about 90 % to 95% of the MLSS, or approximately 95 to 100% of MLSS heart rate, and a sensation of effort rating of 12 to 14 on a 20 point Borg RPE scale. E2 training results in a slightly elevated blood lactate value when compared to extensive endurance training. This rise in blood lactate probably indicates that a greater number of FTa muscle fibers are being recruited. For that reason, intensive endurance training probably provides a greater stimulus for increasing the aerobic capabilities of both ST and FTa muscle fibers than extensive endurance training.

MLSS. Significant reductions in blood lactate values occur following training intensities that approximate the MLSS, which is about 100 to 106% of MLSS heart rate with a perceived sensation of effort of 14 to 16 on a Borg 20 point scale (Acevedo & Goldfarb, 1989). This adaptation probably occurs because MLSS training overloads aerobic metabolism, without engaging anaerobic metabolism to any great extent. The adaptations associated with MLSS training enhance the rate at which the athlete clears lactate from the working muscle, enabling her/him to exercise at a higher percentage of their Vo_2 max before reaching their MLSS.

Vo_2 max is the maximal amount of oxygen that can be consumed and utilized by the body for approximately 5 to10 minutes, and is commonly referred to as aerobic power (McArdle, Katch, & Katch, 2001; Snell, 1990). A study conducted by McGehee, Tanner, and Houmard (2005) examined the accuracy of the maximal 30 minute run for estimating the velocity at MLSS. The study concluded that the because of the simplicity of 30 minute maximal run, ease in interpreting the results, and minimal equipment needed, that it can be used by coaches and athletes to estimate MLSS and heart rate at MLSS in an attempt to optimize run training intensity and performance.

E4. Aerobic power training maximally taxes the heart's ability to deliver oxygen rich blood to the body, providing the greatest stimulus for the development of Vo_2 max. Aerobic power training should occur at a speed that is 107 to 110% faster than the MLSS velocity and should produce maximal heart rates as well as a sensations of effort that are greater than 16 on a

20 point Borg RPE scale. Training at this intensity will increase the oxygen use and lactate removal rates of FTa and FTb muscle fibers and will also improve an athlete's ability to withstand acidosis.

Speed or Sprint training. Training activities that utilize primarily anaerobic metabolic processes are classified as speed or sprint training (e.g., Speed 1 [S1], Speed 2 [S2] and Speed 3 [S3]). This type of training is used to enhance an athlete's sprinting speed so that races can be taken out faster, with improved ability to buffer lactic acid, so that speed can be maintained despite the debilitating effects of acidosis.

S1. Speed 1 training is designed to enhance lactate buffering and pain tolerance, anaerobic capacity, and strength endurance. S1 training is characterized by exercises executed at maximal or near maximal speeds for approximately 50 seconds to 3 minutes will fully activate and exhaust the anaerobic glycolitic systems capacity to produce energy, thereby building aerobic capacity (Janssen, 2001). Sensations of effort at this intensity are >19 on the Borg RPE scale. Training to increase anaerobic capacity, therefore, should consist of maximal or near maximal exercise lasting approximately 50 seconds to 3 minutes (Olbrecht, 2001; Wilkinson, 1999). The rest periods between repetitions should be long enough to maintain running form, but not allow full recovery. This means that the recovery periods should be limited to 30 seconds to a few minutes (Janssen, 2001).

S2. Training that is meant to increase the glycolitic enzymes, which regulate the rate of anaerobic metabolism (i.e., anaerobic power) and enhance speed endurance, has been classified as S2 training. Maximal sprinting for 5 to 30 seconds will completely activate the enzymes that regulate anaerobic glycolysis and provide an appropriate stimulus for adaptations to increase the rate of anaerobic glycolysis. Active rest periods long enough to allow full recovery, approximately 3 to 5 minutes, should allow for most of the high-energy phosphate stores to be replenished (Wilkinson, 1999). The number of repetitions that a runner is capable to completing before sprinting form is lost, usually 3 to 10, determines the number of repetitions completed during a training session (Wilkinson, 1999).

S3. The main scope of S3 training is to increase maximum speed, strength, and reaction time. The primary stimulus for S3 training is force of acceleration (Bompa, 1999). Acceleration is the rate of velocity change that allows an athlete to achieve maximum velocity in a minimal amount of time (Gambetta, 2007). Training to enhance acceleration should consist of 0.1 to 5 second bursts of high intensity work periods, 90 to 100% of maximum, with long recoveries, usually 1 to 2 minutes or longer in duration (U.S.A. Track & Field, 2005). Training at this intensity will also activate the phosphate energy system, increasing the activity of the enzymes that release energy through the adenosine triphosphate and creatine phosphate (ATP-CP) reaction.

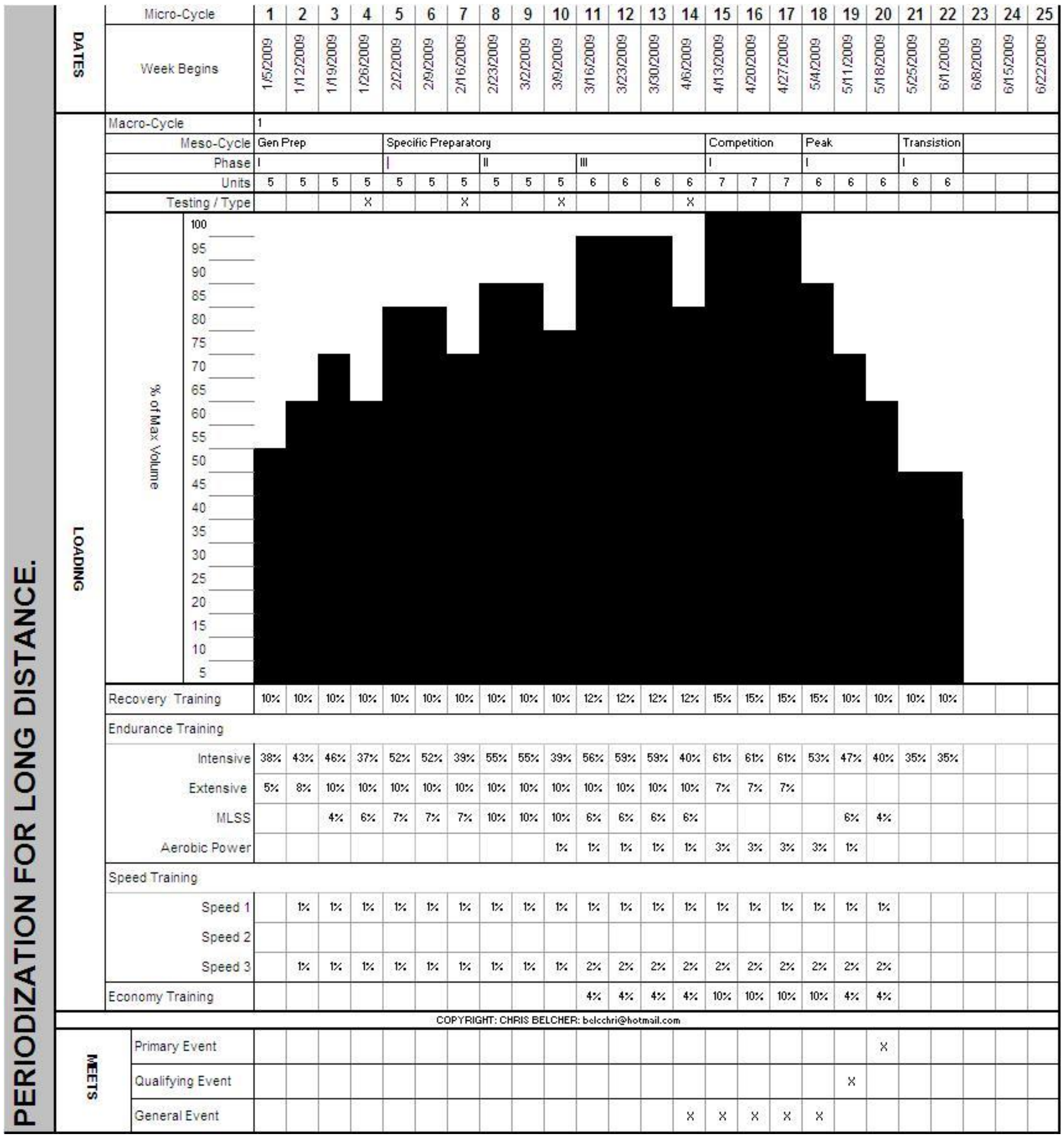
Economy training (ECON). Training used to develop the specialized combination of neuromuscular abilities and metabolic capabilities needed to be successful in a specific event is classified as economy training. Training at competition specific velocities allows athletes to become more efficient at performing the movements associated with that exercise, which reduces the exercise energy requirements, allowing the athlete to perform the exercise with less effort.

Summary. Table 1 presents each of the nine training zones and the approximate measures and physiologic metrics associated with velocity, blood lactate, heart rate and ratings of perceived exertion for each zone. Classifying the velocities used in training into standardized categories that can be specified in terms of readily identifiable physiologic metrics (i.e., HR, Borg RPE), enhances the exercise specific training adaptation precision with which coaches can prescribe and monitor training and anticipated training adaptations. The guidelines provide a common language to allow and facilitate coaches' and sport scientists to more easily communicate with one another, help coaches make training recommendations and prescriptions based on sport science and related exercise physiology.

Training Intensity Guidelines Seasonal Application

Periodization of the training process is the systematic organization of a training year and/or season into distinct, smaller periods of a more manageable size, each of which are attributed specific performance and/or developmental targets. Contemporary periodization models are based on the following sequence of training and competition; the general preparatory period, the specific preparatory period, the competition period, the taper or peak period, and the off season or transition period (Bompa, 1999; Freeman, 2001; Maglischo, 2003; Olbrecht, 2001; Rowbottom, 2000). The periodization model depicted in Figure 1 provides an example of how specific volumes at each of the nine intensity zones can be used during the general preparatory period, the specific preparatory period, the competition period, the taper or peak period, and the off season or transition period of a 22 week periodized training program for a long distance runner (i.e., 5000, 8000, half marathon and marathon).

Figure 1
Training Intensity Guidelines Derived From the Literature Review



General preparatory period. The aim of the general preparatory period is to re-introduce the athlete to training. A majority of the volume completed should be within the extensive and intensive endurance training zones (i.e., 80 to 95% of MLSS velocity, 90 to 100% of MLSS heart rate or a sensation of effort between 10 to 14 on a 20 point Borg RPE scale). The primary goals of this period are:

- Improve rates of oxygen consumption and lactate clearance from slow twitch muscle fibers.
- Improve or maintain anaerobic power.
- Maintain aerobic and anaerobic muscular endurance.
- Increase muscular strength.

Specific preparatory period. During the specific preparatory period the training emphasis is focused on increasing volume and improving endurance. The primary difference between the general preparatory period and the specific preparatory period is that a greater amount of volume will be completed at the MLSS and aerobic power training intensity levels. The primary goals of the specific preparatory period are:

- Continue to improve rates of oxygen consumption and lactate clearance from slow twitch muscle fibers.
- Continue to improve or maintain anaerobic power.
- Continue to maintain aerobic and anaerobic muscular endurance.
- Continue to increase muscular strength.
- Improve rates of oxygen consumption and lactate clearance from fast twitch muscle fibers.

Competition period. During the competition period the coach must adjust the distribution of volume and intensity to compensate for various competitions and the event area the athlete specializes in (Bompa, 1999; Freeman, 2001; Maglischo, 2003; Olbrecht, 2001). The primary goals of the competition period are:

- Maintain rates of oxygen consumption and lactate clearance from slow twitch muscle fibers.
- Improve anaerobic power.
- Improve aerobic and anaerobic muscular endurance.
- Improve athlete’s ability to perform at race pace.

Peak or taper period. The peak or taper period usually last one to two weeks and coincides with the most important competition of the year. The primary goals of the peak or taper period are:

- Maintain rates of oxygen consumption and lactate clearance from slow twitch muscle fibers.
- Maintain or improve anaerobic power.
- Maintain or improve aerobic and anaerobic muscular endurance.
- Maintain or improve athlete's ability to perform at race pace.

Off season or transition period. The primary goal of the off season or transition period is to allow the athlete to recover from the physical and psychological stresses of the training year and/or season and to complete the minimal amount of training necessary to maintain the underlying bio-motor and metabolic adaptations obtained during the training year (Bompa, 1999; Freeman, 2001; Maglischo, 2003; Olbrecht, 2001).

Summary. The seasonal application of the training intensity guidelines (i.e., the general preparatory period, the specific preparatory period, the competition period, the taper or peak period, and the off season or transition period) provides coaches with a training roadmap based on scientifically validated measures of training intensity (Belcher & Pemberton, 2012) through which training intensities and associated workload volumes can be adjusted, adapted and tailored to individual and team needs. As such, it has the potential to help coaches more effectively determine, prescribe, and monitor training intensity and workload volume, and thereby obtain the desired training physical effects while limiting overtraining. This assertion was confirmed by the coaches to whom the guidelines were distributed.

Coaches Commentary – Utility of the Training Intensity Guidelines

The development of training specific knowledge among sport coaches is a complex process that requires the pursuit of individualized and usually impromptu learning pathways (Knowles, Gilbourne, Borrie, & Nevill, 2001). Generally, coaches develop their expertise from reflecting upon their own experiences as performers, their experiences from previous coaching situations, and from observing and communicating with their coaching colleagues. In addition, according to Quinlan (2002) coaches' value experience and practical knowledge acquired from participation in sport and from other coaches above knowledge gained from sports science research. Therefore, it was not surprising that, in general, the coaches' commentary regarding the utility of the guidelines indicated that their knowledge and training practices were derived largely from personal interpretations of previous competitive and coaching experiences.

For this inquiry, following the validation of the training intensity guidelines, two high school and two collegiate track and field/cross country coaches were recruited to participate in one-on-one researcher-coach meetings wherein educational and informational material, inclusive of the guidelines were presented. These meetings lasted approximately 30 minutes. Approximately two weeks after this meeting a semi-structured follow-up interview was conducted to explore each coach's receptivity to, and perceived utility of, the guidelines. All interviews were audio taped. At the conclusion of each interview, coaches were thanked for their time and input. Interview data were then transcribed verbatim, read and reread by the researcher, and a peer researcher (i.e., a member of the researcher's dissertation committee), in order to identify emerging themes (Bogdan & Biklen, 1998; Thomas, 2006). A general inductive approach was employed to analyze the qualitative data (Thomas, 2006).

Standardized training intensity guidelines as a tool to plan objective workloads. All of the coaches indicated that they believed that the guidelines could be used as a tool to enhance their ability to plan more objective training intensity workloads. For example, one college coach stated, "…You can be more accurate with paces you run everything at." Similarly, the high school coaches commented that the guidelines would enhance their ability to plan more objective workloads, and provided a more objective "measuring stick" than the methods they were currently using to determine training intensity. As such, these coaches felt the guidelines would allow them to better "track" and "categorize" their training prescriptions. Additionally, all four coaches believed the guidelines would allow them to better tailor workouts to specific athletes. According to one Coach, ". . . what I really like, about this. . . I think it actually permits, the coach to be able to be more individualized.

Standardized training intensity guidelines as a tool to understand modern trends, advances in sport science, etc. College and high school coaches indicated that they believed the guidelines would help them more easily understand modern trends, advances in sport science, and track and field training strategies. Most strikingly however, the main theme that emerged focused on the dissemination of knowledge among coaches. A college coach indicated that the guidelines would assist him not only in relating to other coaches, but also across a variety of different sports. He said, ". . . I think you will be able to relate more to elite coaches, their articles, their training methods, you can use it to relate across sports as well, bicycling, swimming, any endurance sport. . . ." Similarly, a high school coach believed that the guidelines would allow him to better understand what other sports, and in particular, what other coaches were doing, ". . . by using those intensity levels you can look at the workout and then you can go, 'Ok, now wait a minute, how does that fit in. Oh, I can see now why.' It at least opens the door to understand why they are doing it."

Standardized training intensity guidelines as a tool to enhance communication between coaches, athletes, and sport scientists. Similar to the utility expressed relative to understanding modern trends and training, all of the coaches believed that the guidelines could be a useful tool to allow coaches to more easily communicate with other coaches, athletes, and sport scientists. When asked to identify strengths associated with the guidelines, all coaches were quick to note the value of common terminology and associated terminology understanding—

definitions. A college coach captured this sentiment commenting on the "broad range" of information associated with and used to develop the guidelines:

> The strength is, in my mind. . . the broad range that you cover, you have gone over every aspect of training for an endurance athlete. . . . what I need to do now is take what I have learned from what you have done, and try to, you know, quantify it in a way that will. . . make it useful to me.

The other college coach stated, "I think the research is a big strength. . . the terminology and the stuff you do is proven, you know, to work, and that's legit." Additionally, this coach believed that the amount of information and the way it had been used to devise the guidelines were strengths, ". . . it's nice to have the specific stuff there. It's nice to have it all broken down. And I think the plus with this is that it, it's, it's all there. . . it's very specific and it gives a lot of detail. . . it gives examples. . . it gives possibilities. . . ."

Summary

The training intensity guidelines developed and described in this paper provide track and field/cross country coaches with scientifically validated measures of training intensity (Belcher & Pemberton, 2012) that are readily accessible, identifiable and usable. These measures are organized and presented within the broader framework of a seasonal training periodizational model (i.e., a seasonal training program roadmap). As indicated by the coaches to whom the guidelines were distributed, they were perceived to be useful in planning objective workloads, helping them stay abreast of and understanding modern trends, and enhancing communication among and between coaches and the exercise science community.

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